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With the Author's Compliments.

BIOLOGY AND MEDICINE.

BY

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BIOLOGY AND MEDICINE.[1]

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It is a great pleasure to bring hearty congratulations to the University and the city of Chicago upon the completion of the Hull Biological Laboratories. This University, the offspring of unexampled private munificence, marvellous in its birth and infancy, and clearly destined to great achievements for education, for science and for humanity, may well rejoice upon this occasion, but Miss Culver, by her beneficent gift, has earned the gratitude not of this University alone, but of all interested in the progress of the biological sciences. A gift of such magnitude as this one, devoted to "the increase and spread of knowledge within the field of the biological sciences" is of far more than any local significance. It must awaken the cordial interest far and near of those who understand the scope and meaning of the sciences of organic nature. What is here planned and has already been accomplished, gives assurance that the wishes of the donor and the expectations of others will be amply fulfilled, and that in these laboratories in unusual measure will knowledge of the forms and activities of living things grow and hence be diffused.

[1] Address delivered at the dedication of the Hull Biological Laboratories at the University of Chicago, July 2, 1897.

Laboratories are now so universally recognized as essential for the systematic study and advancement of all physical and natural sciences, that we can hardly realize that they are almost wholly the creation of the last three-quarters of the present century. With the awakening of scientific thought in Western Europe in the fifteenth and sixteenth centuries, natural phenomena again began to be studied by those methods of exact observation and experiment which had received their last fruitful application centuries before in the hands of the natural philosophers and physicians of Greece and Alexandria. For the purposes of such study, learned academies and societies were founded, botanical gardens were planted, explorations and collections of natural curiosities were made, apparatus was devised and individual investigators had their scientific workships. All of these material circumstances greatly promoted scientific inquiry and discovery, but with one exception they did not lead to the formation of laboratories freely open to students and investigators. The exception was the establishment of laboratories for the study of human anatomy.

It is of no little interest, both for the history of biology and for that of science in general, that the first laboratory for the training of students was the anatomical laboratory. For over six hundred years there has been at least some practical instruction in anatomy, and for over three hundred years there have existed anatomical laboratories for students and investigators. Until the end of the first quarter of the present century there was no branch of physical or natural science, with the exception of anatomy, which students could study in the laboratory. Only in this subject could they come into direct personal contact with the object of study, work with their own hands, investigate what lay below the surface, and acquire that living knowledge which alone is of real value in the study of natural science.

The era of modern teaching and investigating laboratories was ushered in by the foundation of one devoted to another of the biological sciences. In 1824 Purkinje established a physiological laboratory in Breslau which antedated by one year Liebig's more famous chemical laboratory in Giessen. This

latter, however, which is usually, and, as we have seen, not quite correctly, considered to be the first of modern teaching laboratories, exercised the determining influence upon the establishment and organization of scientific laboratories in general. The significance of Liebig's memorable laboratory is that it provided a place, furnished with the needed facilities and under competent direction, freely open to properly prepared students and investigators for experimental work in the entire field of the science to which it was devoted. Such an impressive illustration of the value of laboratories for instruction and research could not fail to be followed by other departments of science. In this movement for the establishment of laboratories, Germany has been from the beginning the leader, and by their instrumentality she has secured the palm for scientific education and discovery.

We owe especially to Louis Agassiz the introduction into this country, fifty years ago, of laboratory methods in biological study, but it is only within very recent years that nearly the whole field of biology has been represented among us by laboratories worthy of the name. To the small number of suitably equipped biological laboratories existing in this country those whose opening we are assembled to celebrate, make a most notable addition, unsurpassed, I believe, in construction, in equipment, in plan of organization, and in opportunities for scientific work.

Modern laboratories have completely revolutionized during the past half century the material conditions under which scientific work is prosecuted. They have been the great instrument of the unexampled progress of the physical and natural sciences during this period. Their educational value cannot well be overestimated. They impart, or should impart, to the student something of the scientific habit of thought which is no less valuable in daily life and in other pursuits than in science. At the present day no University can hold even a respectable place in the march of education and progress unless it is provided with suitable scientific laboratories, and it is one of the glories of this University that this conception prevailed and bore fruit at its inception. The establishment and sup-

port of good laboratories require large outlays of money, and it is chiefly this requirement which calls for endowments of Universities far surpassing anything needed but a few years ago. But the benefits to mankind derived from such endowments outweigh, beyond all computation, the money expended which, as has been truly said, is "a capital placed at a high rate of interest."

One sometimes hears the remark, and it is of course true, that large endowments, palatial buildings, splendid laboratories do not make a University. The breath of life, the vitalizing principle, must come from those, both teachers and students, who work within their walls. If the phenomena of nature could be learned by contemplation and by hearsay, that famous University which consisted of a log with Mark Hopkins at one end and the student at the other, might exist somewhere outside of the imagination. But knowledge of nature is not to be acquired otherwise than by observation and experiment, for which the facilities at the end of a log are somewhat inadequate. The great teachers and investigators are likely to be attracted to those Universities where the resources and opportunities for their special work are the most ample.

Laboratories are only workshops; that which is of vital importance is what is done within them. Provision has been made in the Hull Laboratories for the cultivation of all departments of what is ordinarily called biology. The domain of biology embraces all living things, both vegetable and animal. Of vital manifestations it is only some of the mental operations and doings of human beings which the biologist at present excludes from his survey, and even this self-sacrificing curtailment of his province may not be enduring.

The main directions of biological study relate to the forms and anatomical structure, however minute, of living organisms, to their functions or activities, to their developmental history, both individual and ancestral, to their systematic affinities and classification, and to their distribution over the globe in present and in former geological epochs. This vast field of study is far more than can be compassed by one man,

however versatile and industrious, or in one laboratory. It necessitates such specialization and subdivision of labor as is represented by these laboratories and by those appointed to conduct the work in them.

All that relates to the vegetable kingdom, whether it be anatomical, physiological or paleontological, is included under botany. The historical development of this science has been far more consistent and symmetrical than that of animal biology. In the latter the central position is appropriately occupied by zoology in the widest sense. Unfortunately the term zoology has not had the same comprehensive meaning in reference to animals that botany has in reference to plants, but there is a growing tendency, which I am glad to see is here recognized, to include under the designation "zoology" more and more of animal biology, and especially to discard the artificial distinction between zoology and comparative anatomy, a distinction which can be traced historically to the early development and exceptional position of human anatomy, to which I have already alluded. Not less important than the study of organized form and structure, and inseparably intertwined with it, is that of physiology, which concerns itself with the properties and actions of living beings. Subordinate to physiology, but still deserving recognition as a specialized biological science, is physiological chemistry, which is most fruitfully cultivated by one trained both as a chemist and as a biologist, who gives his whole time to the subject. The study of the structure and functions of the nervous system has become so specialized and has such important relations to psychology, that neurology has here received special recognition as a separate department. The same is true of paleontology, which forms a connecting link between biology and geology, and which has shed most valuable light upon fundamental problems concerning the origin and development of animals and plants.

There are some who see in the setting up of all of these divisions and subdivisions of biological science peculiar perils resulting from the severance of natural relations and loss of perspective. This is the familiar cry of the general worker

against the specialist, a cry which, however loudly uttered, will not be heeded. Where proper organization exists, I do not share these apprehensions. The principle of specialization and subdivision of labor has been the great factor in scientific progress. Whenever a body of scientific knowledge has reached a stage of development in which its extent is considerable and its problems and the methods of attacking them are special, it is convenient and proper to recognize it as a branch of science whose interests will be best furthered by workers specially trained to its service.

But while conceding to the fullest extent the practical benefits which attend the separate cultivation of different departments of biology, I would even more strongly emphasize the essential unity of the biological sciences. In essence these sciences constitute but one science, and the great service of the word "biology" in its present use is to embody this conception. The fundamental problems everywhere in biology are the same, the determination of the structure and the properties and the laws controlling them of living matter. In whatever department knowledge be gained as to these fundamental questions, it is a contribution to all departments of biology. The expansion of our knowledge brings closer together all physical and natural sciences, physics with chemistry, and both with biology. It is of incalculable advantage that the surfaces of contact between the different branches of biological study should be kept clearly in view, and that knowledge gained by one should be made readily available for others. Hence it seems to me that the general plan of organization of these laboratories, providing as they do for special development in all proper directions of biological study, while retaining the conception of biology as one science, is eminently wise.

It would be a hopeless task for me to attempt to indicate to you all of the more important questions in which biologists at the present time are especially interested, even if I were myself familiar with them all. They penetrate into all provinces of life and relate to such matters as the complex organization of cells, the problems of heredity and development, the causes

of variation in living organisms, the influence of physical and chemical agencies, and in general of environment, upon the behavior of living cells and organisms, the relations of micro-organisms to fermentation and disease, the finer architecture of the central nervous system, and countless other themes. An especially interesting and new direction of development, to which the biological department of this University has made important contributions, is the application of the experimental method to the solution of certain morphological problems. From this source we may reasonably expect valuable light to be thrown upon the great problems of development, variation and heredity, and thereby we may acquire a clearer and more accurate insight than we now possess into the factors concerned in organic evolution.

No branch of human knowledge exceeds in interest and importance the study of biology; none has made greater advances during this century of scientific progress; none is of more importance to human welfare; none has more deeply impressed modern philosophic thought. Biology has profoundly influenced man's attitude toward Nature and the views as to his own position in the scale of being. It has important bearings upon social and moral questions. With true religion it has no contest, whatever may have been its influence upon dogmatic theology. It reveals the marvellous fitness of organic nature, and it cultivates one of the finest human sentiments, the love of nature. Who but a biologist, who was also a poet, could have sung of the chambered nautilus?

> "Year after year beheld the silent toil
> That spread his lustrous coil;
> Still, as the spiral grew,
> He left the past year's dwelling for the new,
> Stole with soft step its shining archway through,
> Built up its idle door,
> Stretched in his last-found home, and knew the old no more."

To those who seek the practical utility of scientific study biology can show its triumphs, but here as elsewhere in science the important discoveries which have found useful applications have been made by the devotees of pure science rather than by those who make technical utility their guiding principle.

No more striking illustration of the practical benefits conferred by biological discoveries can be given than that derived from the investigation of those lowly micro-organisms which are partly our friends, the preservers of the very existence of life upon this globe, and in smaller part our enemies, the causes of infectious diseases. It would be a long story should I attempt to rehearse the useful discoveries in this domain; how Pasteur saved the silkworm industries of France by his studies of a microscopic parasite; how agriculture and dairies and industries concerned with fermentative processes have been benefited; how preventive inoculations have saved the lives of thousands of animals; how surgery has been revolutionized by Lister's application of Pasteur's discoveries; how the scientific study of immunity has opened up new vistas in preventive and curative medicine, as exemplified by the antitoxic treatment of diphtheria and preventive inoculations for rabies, which have led to the saving of untold thousands of human lives. All of the money ever expended for the promotion of biological science has been repaid a thousand fold by the useful applications of biological discoveries, and in making this statement in this presence I trust that I shall not be thought for a moment to countenance that Philistine view of science which would estimate its value in money or in immediate practical utility.

I have already had occasion to touch upon another side of biology, which is not at present here provided for and which may not be so familiar to all as a biological science. I refer to pathology or the study of life in its abnormal forms and activities. This is the pure science of medicine as distinguished from the art of healing. It is just as truly a department of biology as is the study of normal life. The relations of pathology to practical medicine are so intimate that the broader conception of this science as a part of biology is not always appreciated. Nevertheless pathology may be cultivated as a science no more subordinated to practical ends than is any other natural science. Its subject matter is any living thing which deviates from the normal condition. Its province is to investigate abnormal structure, disordered function and the

causes of these abnormalities. Pathological biology must rest upon a knowledge of normal biology. Between these two great divisions of biology no sharp lines of demarcation can be drawn. The province of one encroaches at many points upon that of the other and they are capable of yielding each other mutual aid.

Although certain directions of pathological study can be followed in a University independently of a medical school, the natural environment of a pathological laboratory is the medical school and hospital, where it can obtain the necessary material for study. Here only can pathology flourish in its entirety.

At the exercises connected with the laying of the corner stones of these laboratories, President Harper uttered these significant words: "In laying these corner stones to-day we are laying the foundations of a school of medicine, for aside from the distinct work outlined in each department there is that great and important service to be rendered in the establishment of a school of medicine, the chief work of which shall be investigation." It will not therefore be out of place at the dedication of these laboratories if I say a few words concerning their relations to the proposed school of medicine and the need of such a school.

A university is the historical and proper place for the establishment of a medical school. Before there was a school of law at Bologna or of theology at Paris, there was a school of medicine at Salernum. For centuries all that there was of biology was to be found in the medical faculty. The union between medical school and university is of mutual advantage and each receives renown from the other. The distinction of great universities has often rested in no small measure upon their medical faculties, as witness such names as Johannes Müller, Virchow, DuBois-Reymond, Ludwig, Kölliker, to mention only a few biologists. The advantages to the medical school of this union are manifold. Among the more important of these may be mentioned the encouragement of research, the development of the scientific spirit and of university ideals, the proper maintenance of laboratories, contact with other departments of

science, economy of organization, and improved methods of instruction. To secure these advantages the union must be a real one. There is no saving grace in merely calling a medical school a department of a university. The medical school must be a vital, integral, co-ordinate part of the university. It should also be said in this connection that the granting of the doctor's degree is the function of a university and it is a usurpation for it to be assumed by independent medical schools responsible to nobody.

Medical science and art rest upon a knowledge of anatomy and physiology and these latter subjects are included in the special medical studies. But before undertaking these special studies it is in every way desirable that the students should have had a liberal education which includes a fair training in physics, chemistry and general biology with the ability to read French and German. You not only have here all that is requisite for the training preliminary to medical education, but you have in these biological laboratories the foundation of a medical school and a part of the superstructure. The usefulness of these laboratories, great as it is under existing conditions, would in my judgment be still further enhanced, especially in certain departments, by association with a medical school, and I need not emphasize the enormous value which the medical school would derive from them.

Not only this University but also the city of Chicago by its size and situation offers peculiarly favorable conditions for the foundation of a great medical school such as is here contemplated.

The present state of the science and art of medicine and of medical education renders especially urgent the claims of higher medical education. Medical science has made enormous strides during the last two decades. The present is a period of great and fruitful activity in medicine. New points of view have presented themselves. Problems of the highest importance to science and to humanity are awaiting only suitable opportunity and patient investigation for their solution. Methods of the laboratory are now applied to the practical study of disease for purposes of diagnosis, prognosis and treat-

ment. The practice of the healing art is a far more scientific and rewarding pursuit now than formerly. The great discoveries relating to the agency of micro-organisms in the causation of disease have given a firm basis to preventive medicine, which has as yet been able to utilize only a relatively small part of the available knowledge.

To the new conditions medical education has as yet only imperfectly adjusted itself. The great need of our medical schools is the establishment of thoroughly equipped and well organized laboratories and these require endowments which none in this country possess to any adequate extent and few possess at all.

While the primary aim of a medical school is to train practitioners of medicine and surgery, a great medical school should also advance the science and art of medicine. This art is becoming in increasing degree applied science, and it cannot be fully acquired without training in the biological medical sciences. I think that in a four years medical course, the first two years should be devoted to the study of the fundamental medical sciences, such as human anatomy, physiology, physiological chemistry, pharmacology, and pathology, and the last two to strictly professional training in practical medicine, surgery and obstetrics. It is one of the most important problems of medical education to maintain the proper balance between the purely technical training in the medical art and the study of the medical sciences. The cultivators of pure science in this or any other university need have no fear that the introduction of a medical department, organized in accordance with the present state of medical science, and to meet the existing needs of medical education, will bring any elements unsuited to the highest university ideals.

A suitably endowed medical school united with a university has to-day in this country unequaled opportunities to achieve success, and to confer a great service upon medicine and upon humanity. The need of such schools is everywhere recognized by the medical profession which would give to their establishment enthusiastic support.

For this purpose you will need large endowments. You will require a hospital with dispensary service. This need not be a very large hospital, but it should be entirely under your control. You will require additional laboratories of pathology, hygiene, pharmacology, and physiological chemistry. The teachers selected should be also investigators and those engaged in the scientific departments should be well paid, so that they can give their whole time to their subjects.

Medical education has not been a favorite object of endowment. Its needs are very imperfectly understood by the community, and our medical schools in the past have for the most part not been such as to encourage their support by private beneficence. But these conditions are changing as witness the names of such benefactors of medical education as Johns Hopkins, Vanderbilt and Mary Garrett.

Every one who has a patriotic pride in seeing this country take its proper place in the great movement forward in medical science and education, would rejoice to see here in connection with this University and in Chicago, such a medical school as I have endeavored to indicate. In no other direction could this University expand with greater promise of usefulness and renown, than in the promotion of the highest medical education. With the unbounded energy and will of this University and of this city, never content with what has been accomplished, however wonderful, but building for the future, it is not too much to say that you could attain something greater and better than has been hitherto achieved.

In conclusion, I desire to express the hope, indeed the conviction, that the Hull Biological Laboratories, which are now open for active work, will fulfil their high promise, will be guided by wisdom, will cherish high ideals, will contribute abundantly to knowledge, will be a centre to which students will wander from far and near, will be a fortress of sound biological thought and education.

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